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This program was a workshop held at Caltech December 1-5, 1997. The documentation for the workshop, including participants, their email and website addresses, the schedule, presentation materials, and a tutorial are available online at the workshop website:

http://www.cds.caltech.edu/vecs.

Because most of the workshop involved computer displayed material, the most suitable format for presentation is the website. The aim was for the workshop to function as nearly paperless as possible. Thus this final report will only give the home page for the website, for which the hardcopy is attached.

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Workshop on Theoretical Foundations of Virtual Engineering and Complex Systems

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AFOSR Grant F49620-97-1-0295
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Abstract

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Home
Background
Tutorial
Schedule
Participants
Local Info

AFOSR/Caltech Workshop on

Theoretical Foundations of Virtual Engineering and Complex Systems

December 1-5, 1997 Caltech

California Institute of Technology

Control and Dynamical Systems

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John Doyle

MURI

Perhaps the most ubiquitous trends in science and engineering involve an increased emphasis on the following

- **complexity:** including higher levels of automation and integration, in the systems we build and study
- **virtuality:** use of computer-based modeling, analysis, and simulation together with supporting information technology, including graphics and visualization.

While these trends are widely discussed and promoted the details are often badly misunderstood.

The premise of this workshop is that the enormous potential suggested by these trends will not be realized without a sound theoretical foundation and associated research community. This workshop will bring together the diverse and currently fragmented research communities that are addressing theoretical aspects of this subject together with engineers and scientists who are involved in complex systems applications. The intent is to foster lively discussion and high levels of interaction. The last day of the workshop, Friday December 5, will be the first annual review of that Caltech MURI program in "Mathematical Infrastructure for Robust Virtual Engineering."

Complexity in engineering and biological systems may fundamentally arise for the same reason: *they have been designed to operate in an uncertain environment, and must be far more robust than the components from which they are built.* In the design of engineering systems, we are now typically less limited by our ability to fabricate materials and components, and more limited by our ability to manage and control the complexities and uncertainties of highly interconnected, heterogeneous systems. The physical sciences are also making more use of virtuality for complex systems to explore the isolated properties of individual materials through molecular scale modeling of growth and fracture, through collective effects on much larger scales including earthquake source dynamics and global climatic change.

The new mantra of "better, cheaper, faster" is also driving complex systems engineering. What is not widely appreciated is the mathematical

and software infrastructure that must exist on top of standard "graphical, VR-based, distributed, object-oriented, web-based, collaborative, paperless,..." information technology in order to achieve the goals of this mantra. To oversimplify somewhat, we appreciate the enormous advances in information technology that make it possible to do convincing-looking computer generated animation of dinosaurs or intergalactic spaceships, or to do web-based distributed collaboration. The ongoing development of these technologies will continue to be important to scientists and engineers, as well as those in entertainment and business. But an entirely different set of tools is needed in addition if one is actually to build a working spacecraft, or more fancifully, a working dinosaur.

There is a technological vacuum between domain-specific computer-aided design (CAD) tools such as in VLSI or mechanical design, or computational fluid dynamics (CFD), or technologies being developed in, say, the ASCI program, and those needed for integrated design of complex heterogeneous systems. It is exactly this vacuum that this workshop is intended to address.
